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Wiederin et al.

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(54) **INJECTION VALVE**

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(51) **Int. Cl.**

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G01N 30/20	(2006.01)
G01N 1/28	(2006.01)

(52) **U.S. Cl.**
CPC ***G01N 1/28*** (2013.01); *G01N 2030/201* (2013.01); *G01N 2030/202* (2013.01); *G01N 2030/207* (2013.01); *Y10T 137/86863* (2015.04)

(58) **Field of Classification Search**
CPC Y10T 137/86863; G01N 2030/201; G01N 2030/202; G01N 2030/207
USPC 137/625.46
See application file for complete search history.

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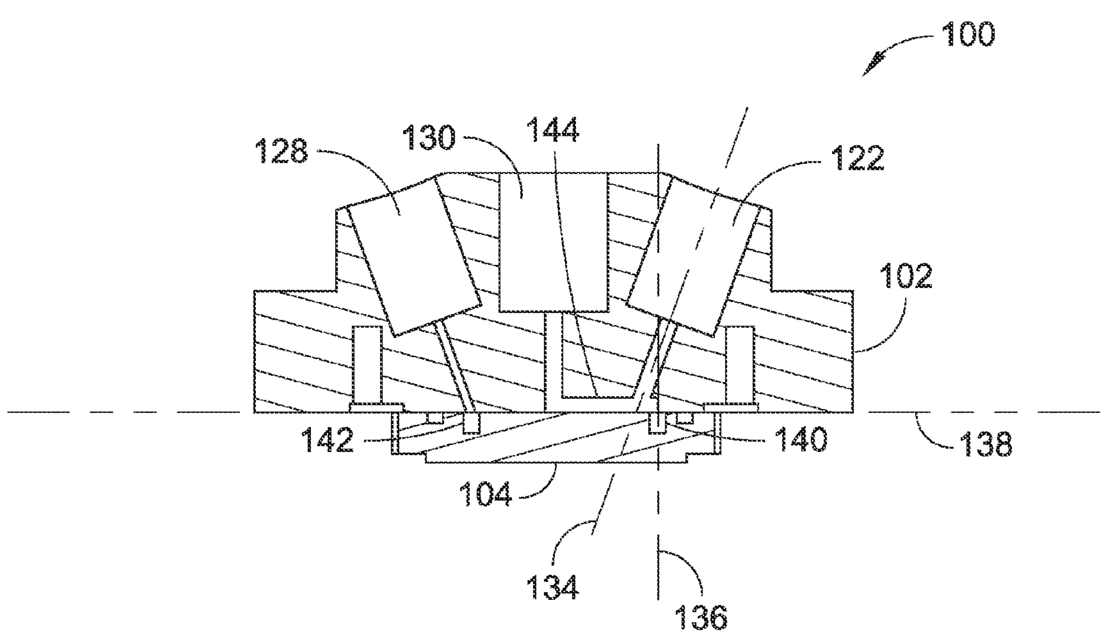
(57) **ABSTRACT**

Valve assemblies are described that provide flow paths in substantially indirect opposition for fluids injected into the valve assemblies for mixing. A valve assembly includes a first valve member having ports configured to receive a first fluid and a second fluid. The valve assembly also includes a second valve member coupled adjacent to the first valve member. The valve assembly defines a first flow path for the first fluid and a second flow path for the second fluid. The first flow path extends from one of the ports of the first valve member toward an interface between the first valve member and the second valve member, and the second flow path extends from a channel defined by the second valve member toward the interface between the first valve member and the second valve member. The second flow path is in substantially indirect opposition to the first flow path.

20 Claims, 6 Drawing Sheets



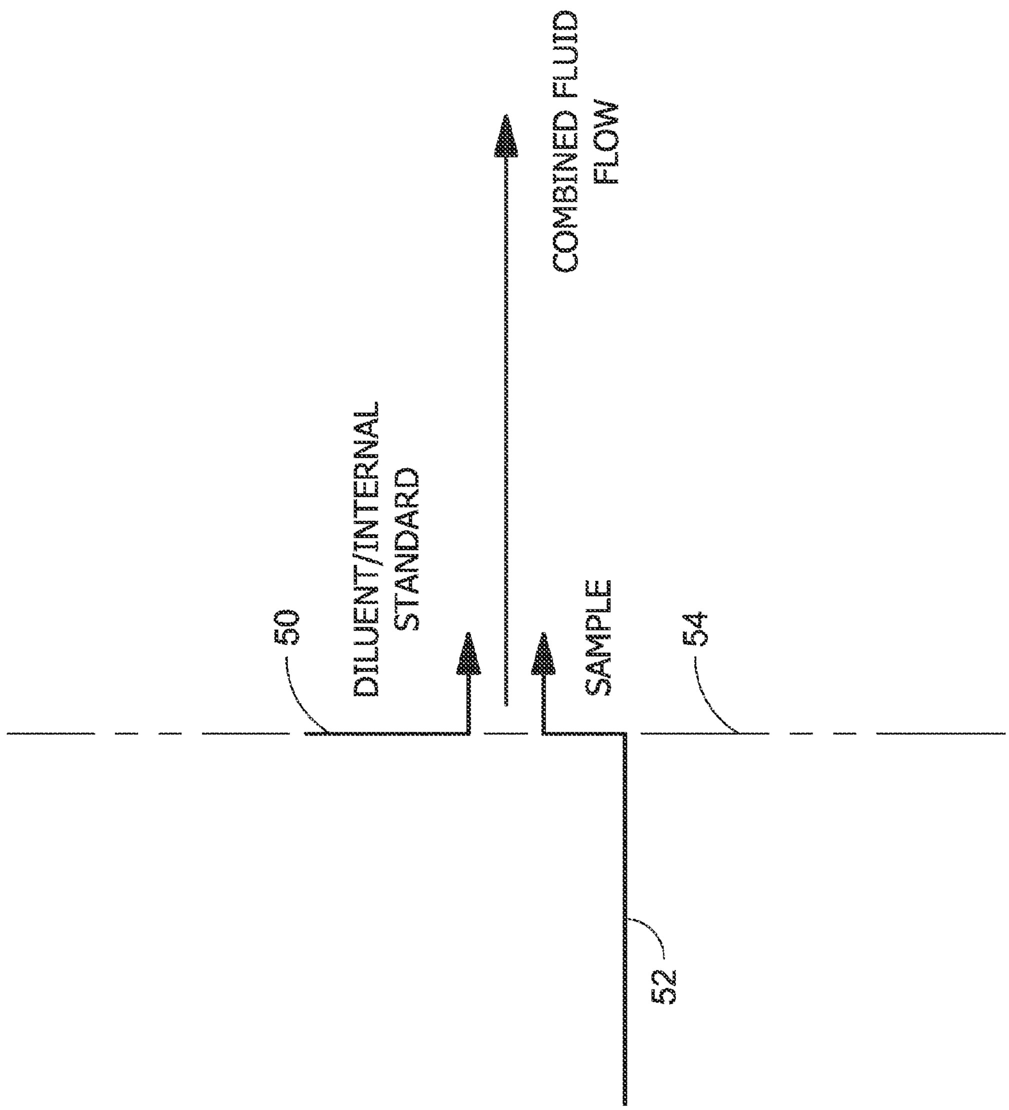

COMBINED FLUID FLOW
DILUENT/INTERNAL STANDARD
SAMPLE
50
54
52

FIG. 1

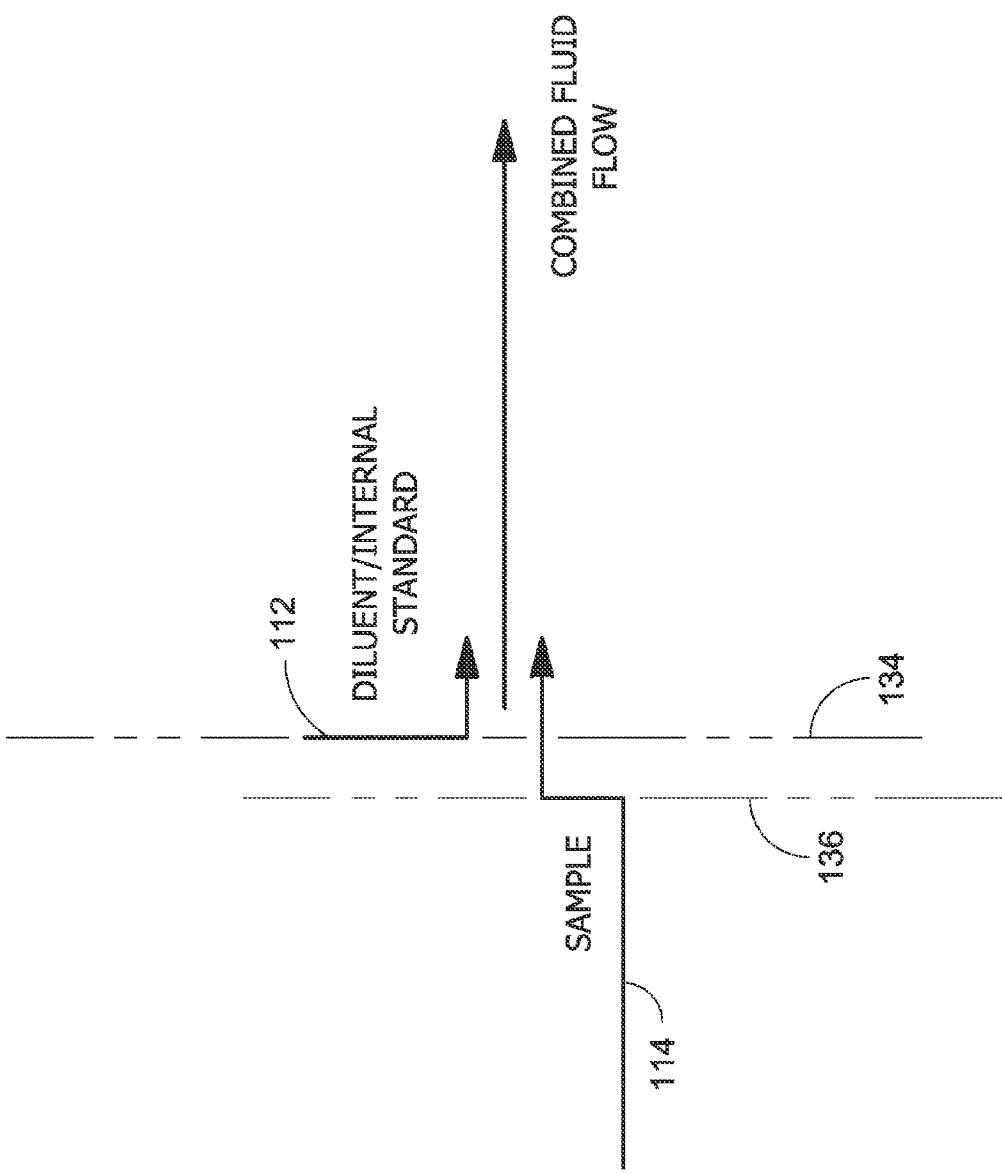

COMBINED FLUID FLOW
DILUENT/INTERNAL STANDARD
112
134
136
SAMPLE
114

FIG. 2A

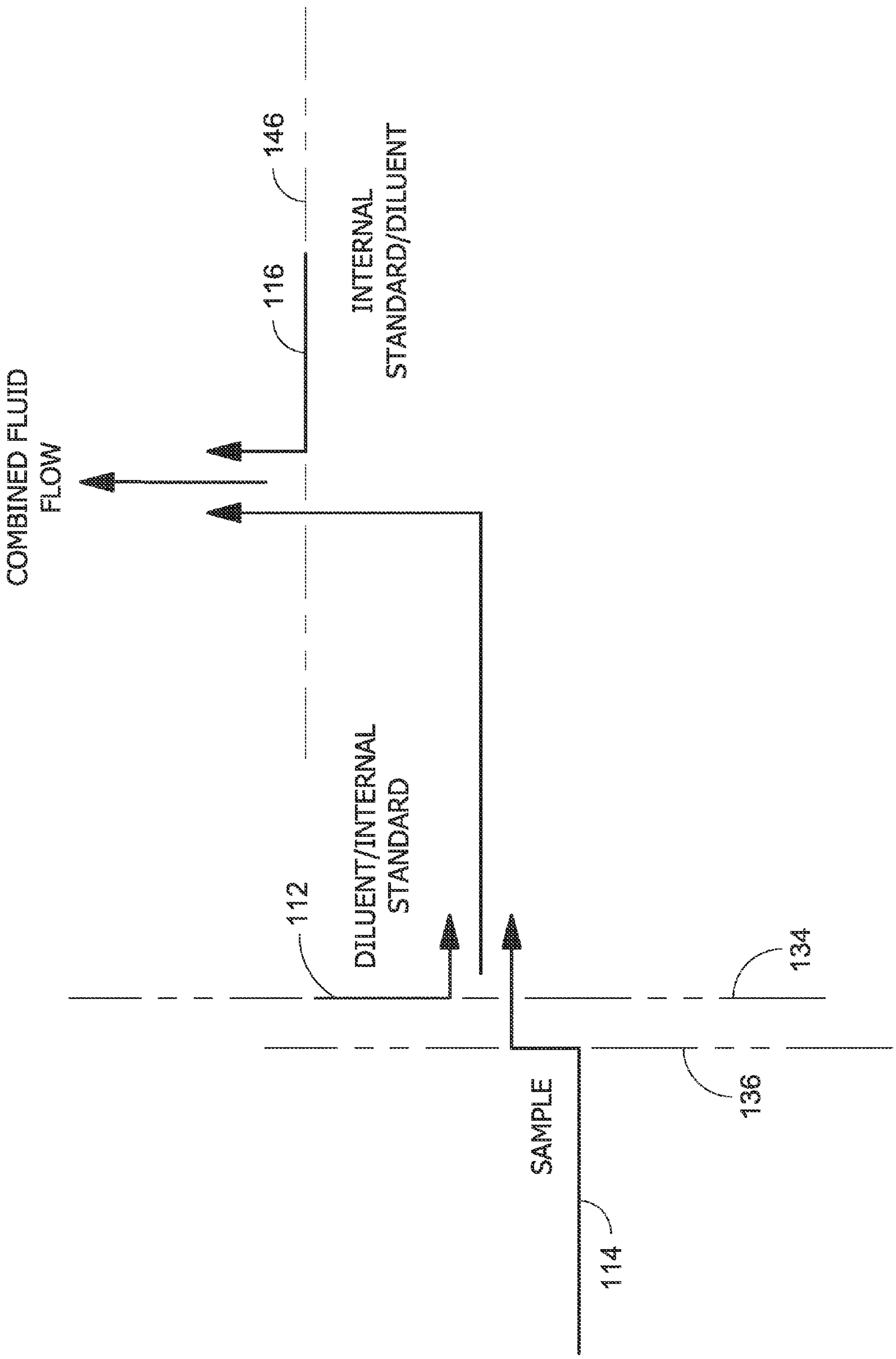

146
116
INTERNAL
STANDARD/DILUENT
COMBINED FLUID
FLOW
DILUENT/INTERNAL
STANDARD
112
134
136
SAMPLE
114

FIG. 2B

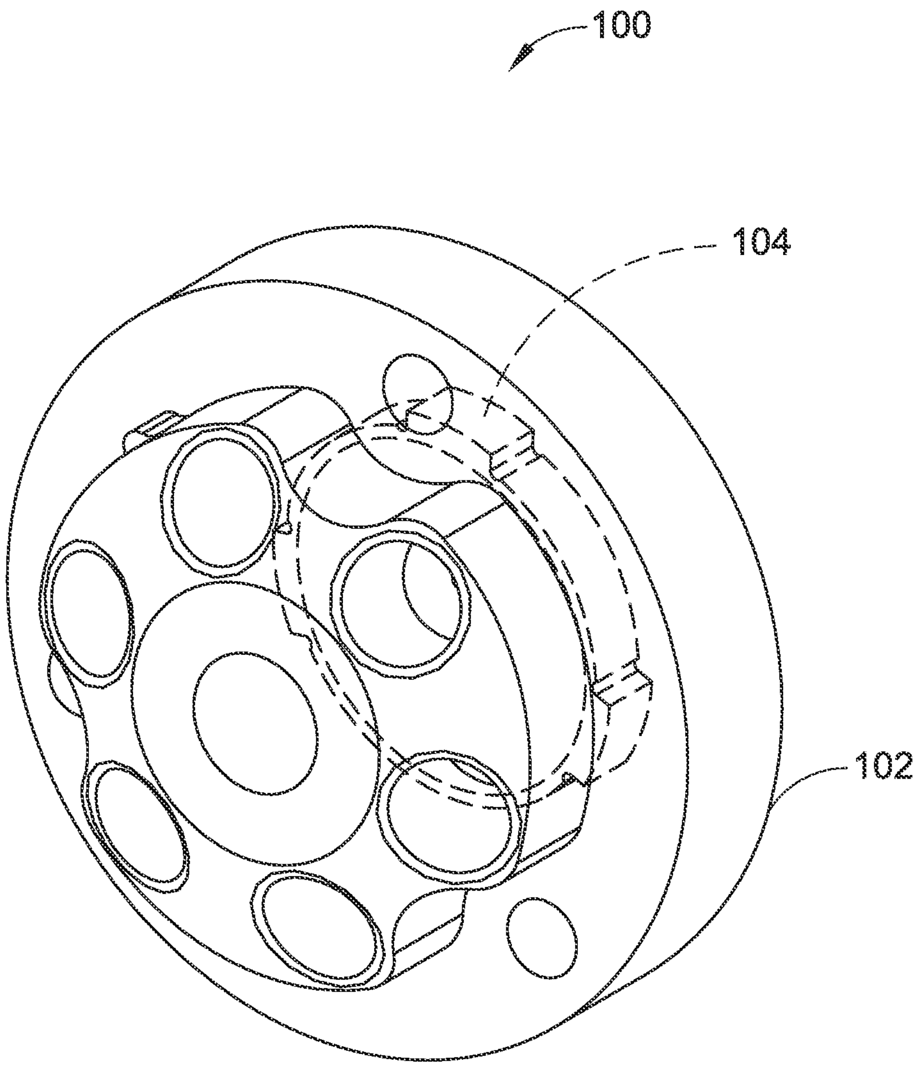


FIG. 3

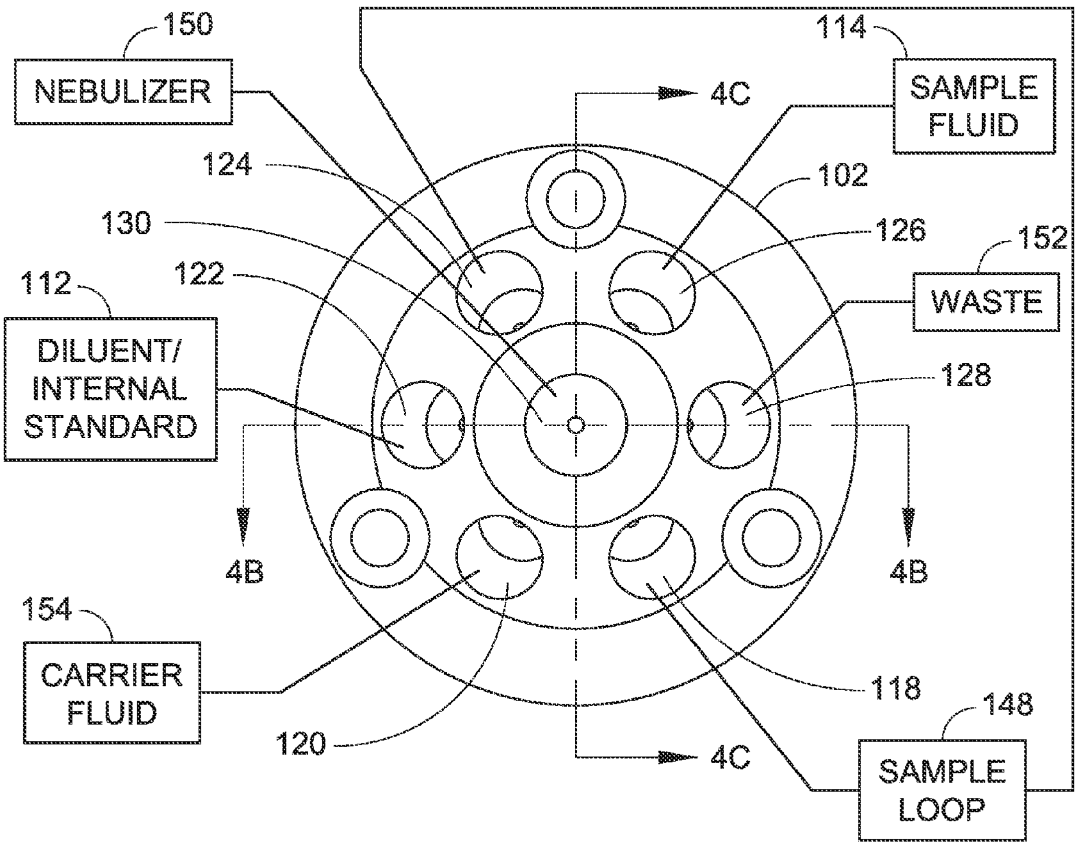

150
NEBULIZER
114
SAMPLE FLUID
4C
124
102
130
126
152
WASTE
112
122
DILUENT/ INTERNAL STANDARD
128
4B
4B
154
CARRIER FLUID
118
148
120
4C
SAMPLE LOOP

FIG. 4A

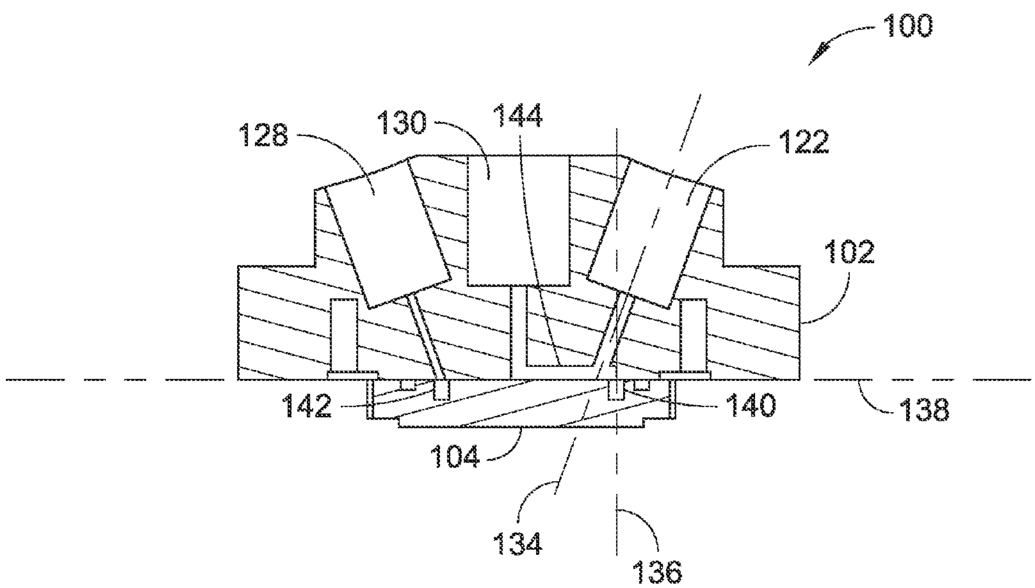

100
128
130
144
122
102
142
140
138
104
134
136

FIG. 4B

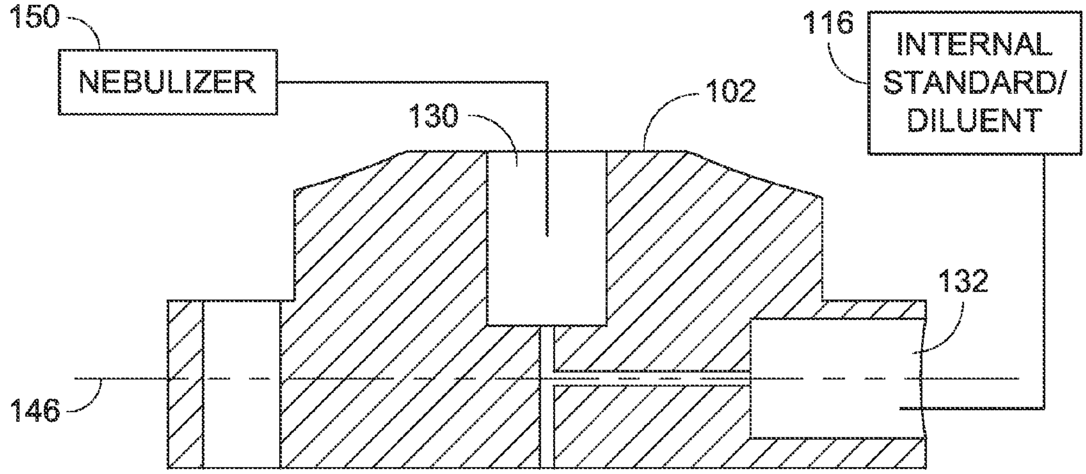

150
NEBULIZER
130
102
116
INTERNAL STANDARD/ DILUENT
132
146

FIG. 4C

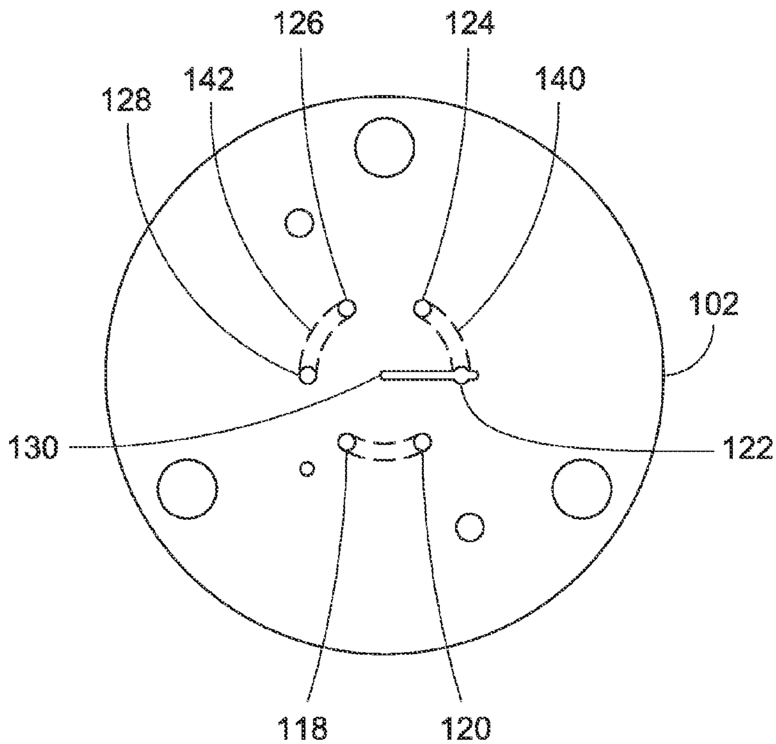

126
124
128
142
140
102
130
122
118
120

FIG. 4D

INJECTION VALVE

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application claims the benefit under 35 U.S.C. §119(e) of U.S. Provisional Application Ser. No. 61/759,549, filed Feb. 1, 2013, and titled "INJECTION VALVE," which is herein incorporated by reference in its entirety.

BACKGROUND

Inductively Coupled Plasma (ICP) spectrometry is an analysis technique commonly used for the determination of trace element concentrations and isotope ratios in liquid samples. ICP spectrometry employs electromagnetically generated partially ionized argon plasma which reaches a temperature of approximately 7,000K. When a sample is introduced to the plasma, the high temperature causes sample atoms to become ionized or emit light. Since each chemical element produces a characteristic mass or emission spectrum, measuring the spectra of the emitted mass or light allows the determination of the elemental composition of the original sample.

Sample introduction systems may be employed to introduce the liquid samples into the ICP spectrometry instrumentation (e.g., an Inductively Coupled Plasma Mass Spectrometer (ICP/ICP-MS), an Inductively Coupled Plasma Atomic Emission Spectrometer (ICP-AES), or the like) for analysis. For example, a sample introduction system may withdraw an aliquot of a liquid sample from a container and thereafter transport the aliquot to a nebulizer that converts the aliquot into a polydisperse aerosol suitable for ionization in plasma by the ICP spectrometry instrumentation. The aerosol is then sorted in a spray chamber to remove the larger aerosol particles. Upon leaving the spray chamber, the aerosol is introduced into the plasma by a plasma torch assembly of the ICP-MS or ICP-AES instruments for analysis.

SUMMARY

Valve assemblies are described that provide flow paths in substantially indirect opposition for fluids injected into the valve assemblies for mixing. A valve assembly includes a first valve member having ports configured to receive a first fluid and a second fluid. The valve assembly also includes a second valve member coupled adjacent to the first valve member. The valve assembly defines a first flow path for the first fluid and a second flow path for the second fluid. The first flow path extends from one of the ports of the first valve member toward an interface between the first valve member and the second valve member, and the second flow path extends from a channel defined by the second valve member toward the interface between the first valve member and the second valve member. The second flow path is in substantially indirect opposition to the first flow path.

This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

DRAWINGS

The Detailed Description is described with reference to the accompanying figures. The use of the same reference num-

bers in different instances in the description and the figures may indicate similar or identical items.

FIG. **1** is a partial diagrammatic illustration of a multiport valve configuration where a sample fluid and a diluent/internal standard meet in direct opposition for mixing.

FIG. **2**A is a partial diagrammatic illustration of a multiport valve configuration where a sample fluid and a diluent/internal standard meet along flow paths in substantially indirect opposition for mixing in accordance with example implementations of the present disclosure.

FIG. **2**B is a partial diagrammatic illustration of a multiport valve configuration where a sample fluid and a diluent/internal standard meet along flow paths in substantially indirect opposition for mixing, and where an internal standard/diluent is further mixed with the combined fluid flow of the sample fluid and the diluent/internal standard in accordance with example implementations of the present disclosure.

FIG. **3** is an isometric view illustrating a multiport flow valve assembly including a stator and a rotor configured to provide flow paths in substantially indirect opposition for fluids injected into the valve assembly for mixing in accordance with example implementations of the present disclosure.

FIG. **4**A is a top plan view of a multiport flow valve stator head with flow paths in substantially indirect opposition for fluids injected into the valve assembly for mixing in accordance with example implementations of the present disclosure.

FIG. **4**B is a cross-sectional side elevation view of the stator head illustrated in FIG. **4**A, further illustrating a rotor interfacing with the stator to form a multiport flow valve assembly in accordance with example implementations of the present disclosure.

FIG. **4**C is another cross-sectional side elevation view of the stator head illustrated in FIG. **4**A.

FIG. **4**D is a bottom plan view of the stator head illustrated in FIG. **4**A.

DETAILED DESCRIPTION

Overview

Multiport valves are typically used to transport sample materials to laboratory equipment for analysis. For example, multiport valves can be used to introduce liquid samples into ICP spectrometry instrumentation for analysis. Multiport valves can also be used to load samples on columns for liquid and/or gas chromatography. Typical valves used in these applications include six-port (6-port), two-position (2-position) rotary valves. Generally, two ports of a rotary valve are connected to an external (sample) loop, one port is connected to a sample source, another port is connected to a carrier source, a further port is connected to a vent (waste), and another port is connected to a nebulizer/column. When the valve is in a first orientation, sample from the sample source flows through the sample loop, while carrier from the carrier source flows directly to a nebulizer/column. When the valve is rotated to a second orientation, the carrier source is connected to the sample loop for injecting the sample contained in the sample loop into the nebulizer or onto the column. In some multiport valve configurations, one fluid is mixed with another fluid by injecting the two fluids into separate ports of a multiport valve. In these configurations, the two fluids meet along flow paths in direct opposition. For example, a diluent/internal standard **50** and a sample **52** are injected into a multiport valve so that the two fluids meet along flow paths **54** in direct opposition.

Valve assemblies are described that provide flow paths in substantially indirect opposition for fluids injected into the valve assemblies for mixing. In some embodiments, a valve assembly includes a first valve member (e.g., a stator) having ports configured to receive a first fluid (e.g., a diluent and/or an internal standard) and a second fluid (e.g., sample fluid). The ports are configured to connect to an external loop (e.g., a sample loop), an output (e.g., a nebulizer, a column, and so forth), and a vent (e.g., waste). The valve assembly also includes a second valve member (e.g., a rotor) coupled adjacent to the first valve member. The second valve assembly defines channels configured to connect the external loop to the second fluid in one orientation (e.g., rotational position) for charging the external loop with the second fluid, and to connect the external loop to the output in another orientation (e.g., rotational position) for supplying the second fluid from the external loop to the output. The valve assembly defines a first flow path for the first fluid and a second flow path for the second fluid. The first flow path extends from one of the ports of the first valve member toward an interface between the first valve member and the second valve member, and the second flow path extends from a channel defined by the second valve member toward the interface between the first valve member and the second valve member. The second flow path is in substantially indirect opposition to the first flow path.

Example Implementations

FIGS. **2** through **4** illustrate an example stator **102** and an example rotor **104** for a valve assembly **100**. The valve assembly **100** includes a first valve member and a second valve member coupled adjacent to the first valve member. As shown, the valve assembly **100** can be configured as a rotary valve assembly having a first valve member comprising a stator **102** and a second valve member comprising a rotor **104** coupled adjacent to the stator **102** so that it can rotate with respect to the stator **102**. The valve assembly **100** is configured to furnish a high degree of mixing between two or more fluids (e.g., a sample fluid and a diluent and/or an internal standard) supplied to instrumentation, such as ICP spectrometry instrumentation, and so forth. In implementations, the valve assembly **100** provides a high degree of mixing at high dilution factors (DF), and can provide more reproducible stabilization times (e.g., for ICP spectrometry) at various dilution factors. It should be noted that while the accompanying figures show the stator **102** and the rotor **104** of the valve assembly **100**, the valve assembly **100** may also include additional components, such as components for holding the rotor **104** adjacent to the stator **102**, and so forth. For example, the valve assembly **100** may further include a drive configured to rotate the rotor **104** and/or the stator **102**, and a housing configured to support the stator **102** and/or the rotor **104** adjacent to the stator **102**.

The stator **102** includes ports configured to connect to an external loop (e.g., a sample loop **148**), an output (e.g., a nebulizer **150**), and a vent/waste **152**. The stator **102** is configured to receive a first fluid (e.g., a carrier fluid **154**), a second fluid (e.g., a sample fluid **114**), a third fluid (e.g., a diluent/internal standard **112**), and/or a fourth fluid (e.g., an internal standard/diluent **116**). The stator **102** includes a first port **118** configured to connect to the sample loop **148**, a second port **120** configured to receive the carrier fluid **154**, a third port **122** configured to receive the diluent/internal standard **112**, a fourth port **124** configured to connect to the sample loop **148**, a fifth port **126** configured to receive the sample fluid **114**, a sixth port **128** configured to connect to waste **152**, and/or a seventh port **130** configured to connect to the nebulizer **150**. In implementations, the stator **102** may also include an eighth port **132** configured to connect to the nebulizer **150**. The eighth port **132** may be positioned in the side of the stator **102** to furnish online dilution of, for example, the sample fluid **114**. For instance, a source of internal standard/diluent **116** can be connected to the eighth port **132**, and the internal standard/diluent **116** can be supplied while the sample fluid **114** and/or the diluent/internal standard **112** is pumped to the nebulizer **150**. The eighth port **132** may also be used to provide a rinse for rinsing the connection to the nebulizer **150**. In implementations, the stator **102** may also include a drain port, which may be connected to a channel in the rotor **104**. In implementations, fluid flow to the ports of the stator **102** can be controlled using an instrument such as a valve controller (not shown).

The rotor **104** includes channels configured to connect the sample loop **148** to the sample fluid **114** in a first (load) orientation for charging the sample loop **148** with the sample fluid **114**, and to connect the sample loop **148** to the nebulizer **150** in a second (inject) orientation for supplying the sample fluid **114** from the sample loop **148** to the nebulizer **150**. For example, the rotor **104** includes a first channel configured to connect the second port **120** to the third port **122** in the first orientation, and to connect the first port **118** to the second port **120** in the second orientation. The rotor **104** also includes a second channel **140** configured to connect the fourth port **124** to the fifth port **126** in the first orientation, and to connect the third port **122** to the fourth port **124** in the second orientation. The rotor **104** further includes a third channel **142** configured to connect the sixth port **128** to the first port **118** in the first orientation, and to connect the fifth port **126** to the sixth port **128** in the second orientation for supplying the sample fluid **114** from the sample loop **148** to the nebulizer **150**.

The valve assembly **100** defines a flow path **134** for the diluent/internal standard **112** and a flow path **136** for the sample fluid **114**. The flow path **134** extends from the third port **122** of the stator **102** toward an interface **138** between the stator **102** and the rotor **104**. The flow path **136** extends from the second channel **140** of the rotor **104** toward the interface **138** between the stator **102** and the rotor **104**. In embodiments of the disclosure, the flow path **134** is in substantially indirect opposition to the flow path **136**. Further, the stator **102** includes a channel **144** configured to connect the flow path **134** to the seventh port **130**. In some embodiments, the stator **102** also includes an eighth port **132** connected to the seventh port **130** to furnish online dilution of the sample fluid **114**. For example, the internal standard/diluent **116** can be supplied to the eighth port **132** via a flow path **146** connecting the eighth port **132** to the seventh port **130**.

It should be noted that while the terms "stator" and "rotor" are used herein to describe the first and second valve members, these terms are provided by way of example only (e.g., to illustrate how these components interface (e.g., rotate) with respect to one another), and are not meant to limit how the valve members can be actuated with respect to an external reference (e.g., valve mounting hardware, or the like). Thus, in one particular example, a component described as a "stator" may remain substantially stationary (e.g., with respect to an external reference, such as valve mounting hardware), and a component described as a "rotor" may rotate with respect to the stator. However, in another particular example, a component described as a "stator" may rotate with respect to a rotor, and a component described as a "rotor" may remain substantially stationary (e.g., with respect to valve mounting hardware). Further, in some implementations, both a component described as a "stator" and a component described as a "rotor" may rotate with respect to an external reference.

CONCLUSION

Although the subject matter has been described in language specific to structural features and/or process operations, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed as example forms of implementing the claims.

What is claimed is:

1. A valve assembly comprising:

a first valve member having a plurality of ports configured to receive a first fluid and a second fluid; and

a second valve member coupled adjacent to the first valve member, the valve assembly defining a first flow path for the first fluid and a second flow path for the second fluid, the first flow path extending from one of the plurality of ports of the first valve member toward an interface between the first valve member and the second valve member, and the second flow path extending from a channel defined by the second valve member toward the interface between the first valve member and the second valve member, wherein the second flow path is in substantially indirect opposition to the first flow path.

2. The valve assembly as recited in claim **1**, wherein the first valve member defines a channel configured to connect the first flow path to a second one of the plurality of ports of the first valve member.

3. The valve assembly as recited in claim **1**, wherein the first valve member comprises a stator and the second valve member comprises a rotor coupled adjacent to the stator.

4. The valve assembly as recited in claim **1**, wherein the plurality of ports is configured to connect to an external loop, an output, and a vent.

5. The valve assembly as recited in claim **4**, wherein the second valve member defines a plurality of channels configured to connect the external loop to the second fluid in a first orientation for charging the external loop with the second fluid and to connect the external loop to the output in a second orientation for supplying the second fluid from the external loop to the output.

6. The valve assembly as recited in claim **4**, wherein the external loop comprises a sample loop, the output comprises a nebulizer, the first fluid comprises at least one of a diluent or an internal standard, and the second fluid comprises a sample fluid.

7. The valve assembly as recited in claim **4**, wherein the first valve member further comprises a port connected to one of the plurality of ports connected to the output to furnish online dilution of at least one of the first fluid or the second fluid.

8. A valve assembly comprising:

a first valve member having a first port configured to connect to an external loop, a second port configured to receive a first fluid, a third port configured to receive a second fluid, a fourth port configured to connect to the external loop, a fifth port configured to receive a third fluid, a sixth port configured to connect to a vent, and a seventh port configured to connect to an output; and

a second valve member coupled adjacent to the first valve member, the second valve member having a first channel configured to connect the second port to the third port in a first orientation for charging the external loop with the second fluid and to connect the first port to the second port in a second orientation for supplying the second fluid from the external loop to the output, a second channel configured to connect the fourth port to the fifth port in the first orientation and to connect the third port to the fourth port in the second orientation, a third channel configured to connect the sixth port to the first port in the first orientation and to connect the fifth port to the sixth port in the second orientation, the valve assembly defining a first flow path for the second fluid and a second flow path for the third fluid, the first flow path extending from one of the plurality of ports of the first valve member toward an interface between the first valve member and the second valve member, and the second flow path extending from a channel defined by the second valve member toward the interface between the first valve member and the second valve member, wherein the second flow path is in substantially indirect opposition to the first flow path.

9. The valve assembly as recited in claim **8**, wherein the first valve member defines a channel configured to connect the first flow path to the seventh port.

10. The valve assembly as recited in claim **8**, wherein the first valve member comprises a stator and the second valve member comprises a rotor coupled adjacent to the stator.

11. The valve assembly as recited in claim **8**, wherein the external loop comprises a sample loop, the output comprises a nebulizer, the first fluid comprises a carrier fluid, the second fluid comprises at least one of a diluent or an internal standard, and the third fluid comprises a sample fluid.

12. The valve assembly as recited in claim **8**, wherein the first valve member further comprises an eighth port connected to the seventh port to furnish online dilution of at least one of the first fluid or the second fluid.

13. A method comprising:

receiving a sample fluid and at least one of a diluent or an internal standard at a valve assembly;

connecting a sample loop to the sample fluid via the valve assembly in a first orientation for charging the sample loop with the sample fluid;

connecting the sample loop to a nebulizer via the valve assembly in a second orientation for supplying the sample fluid from the sample loop to the nebulizer; and

mixing the sample fluid and the at least one of the diluent or the internal standard by introducing the sample fluid and the at least one of the diluent or the internal standard in substantially indirect opposition.

14. The method as recited in claim **13**, wherein the valve assembly comprises a first valve member having a plurality of ports configured to receive the sample fluid and the at least one of the diluent or the internal standard, and a second valve member coupled adjacent to the first valve member, the valve assembly defining a first flow path for the at least one of the diluent or the internal standard and a second flow path for the sample fluid.

15. The method as recited in claim **14**, wherein the first flow path extends from one of the plurality of ports of the first valve member toward an interface between the first valve member and the second valve member, and the second flow path extends from a channel defined by the second valve member toward the interface between the first valve member and the second valve member.

16. The method as recited in claim **14**, wherein the first valve member defines a channel configured to connect the first flow path to a second one of the plurality of ports of the first valve member.

17. The method as recited in claim **14**, wherein the first valve member comprises a stator and the second valve member comprises a rotor coupled adjacent to the stator.

18. The method as recited in claim 14, wherein the plurality of ports is configured to connect to the sample loop, the output, and a vent.

19. The method as recited in claim 14, wherein the second valve member defines a plurality of channels configured to connect the sample loop to the second fluid in a first orientation for charging the external loop with the second fluid and to connect the sample loop to the nebulizer in a second orientation for supplying the second fluid from the external loop to the output.

20. The method as recited in claim 14, wherein the first valve member further comprises a port connected to one of the plurality of ports connected to the output to furnish online dilution of at least one of the first fluid or the second fluid.

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